JOVIAN and SOLAR RADIO DEFLECTION EXPERIMENTS

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OUTLINE

1. History of Radio Tests
2. Quasar Deflection using Jupiter
   (controversial aberration term)
3. Solar bending in October 2005
   (best VLBI determination of γ)

DEFLECTION EXPERIMENTS

Measurements of γ

1919 Sobral Brasil – Eddington Experiment
1967 Radio Experiments better than optical
1974-75 Fomalont & Sramek 35 km. $\Delta\gamma=10^{-2}$
1995 Lebach, Shapiro et al $\Delta\gamma=10^{-3}$
1996 Eubanks & USNO $\Delta\gamma=10^{-3}$
2002 Cassini (grav. redshift) $\Delta\gamma=5\times10^{-5}$!!

2002 Deflection by Jupiter

Why Measure γ Better?

.) measures the degree to which gravity is n
purely local geometric effect.
erration of gravity from moving objects!!

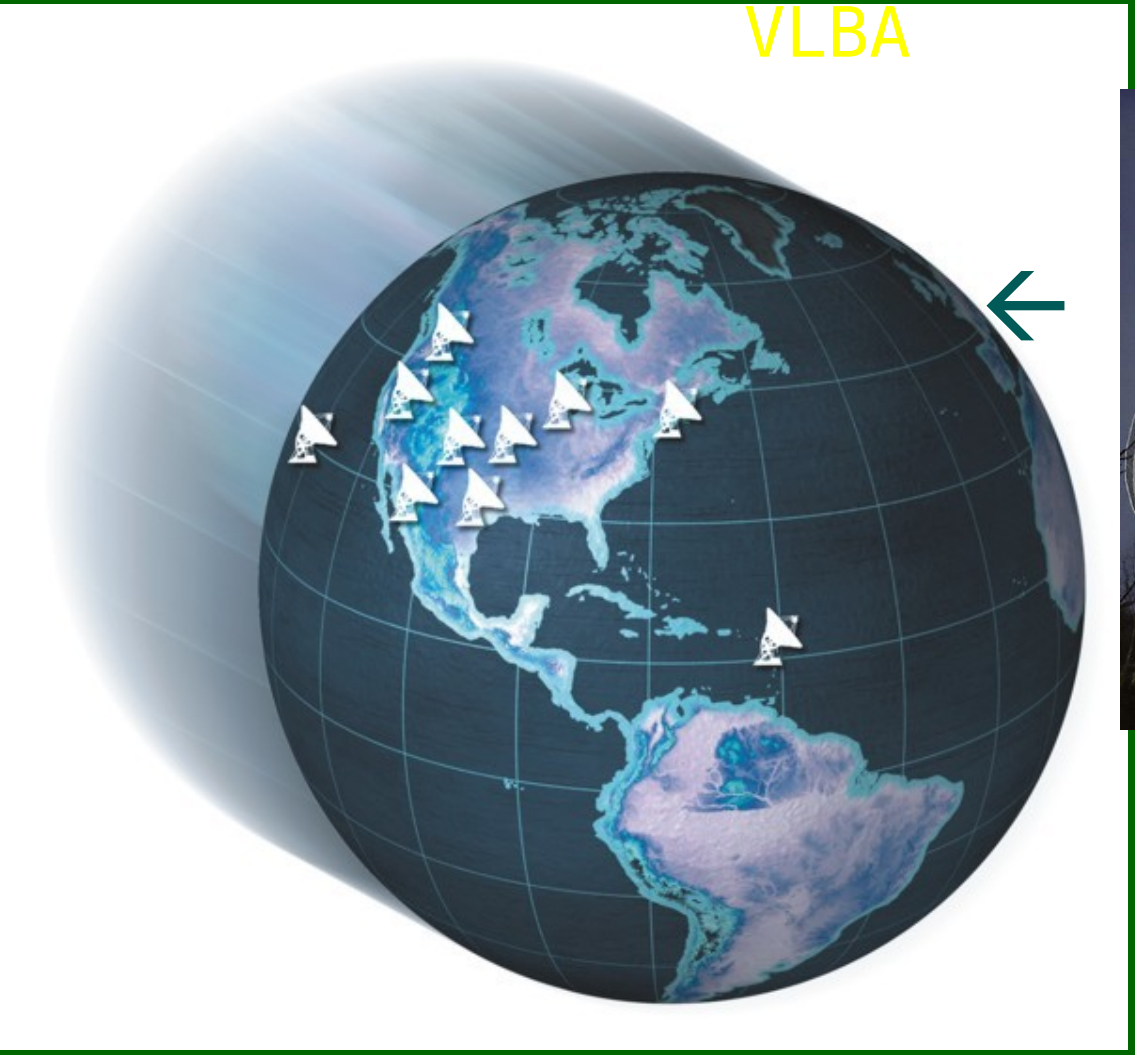
ng range scalar field, λ
riation of G and fine-structure constant
eed of Gravity
ane and String Theories
-metric theories of gravity

$(\gamma - 1) \sim -1 \times 10^{-5}$ to -1×10^{-7}
(note: $\gamma < 1$ expected)

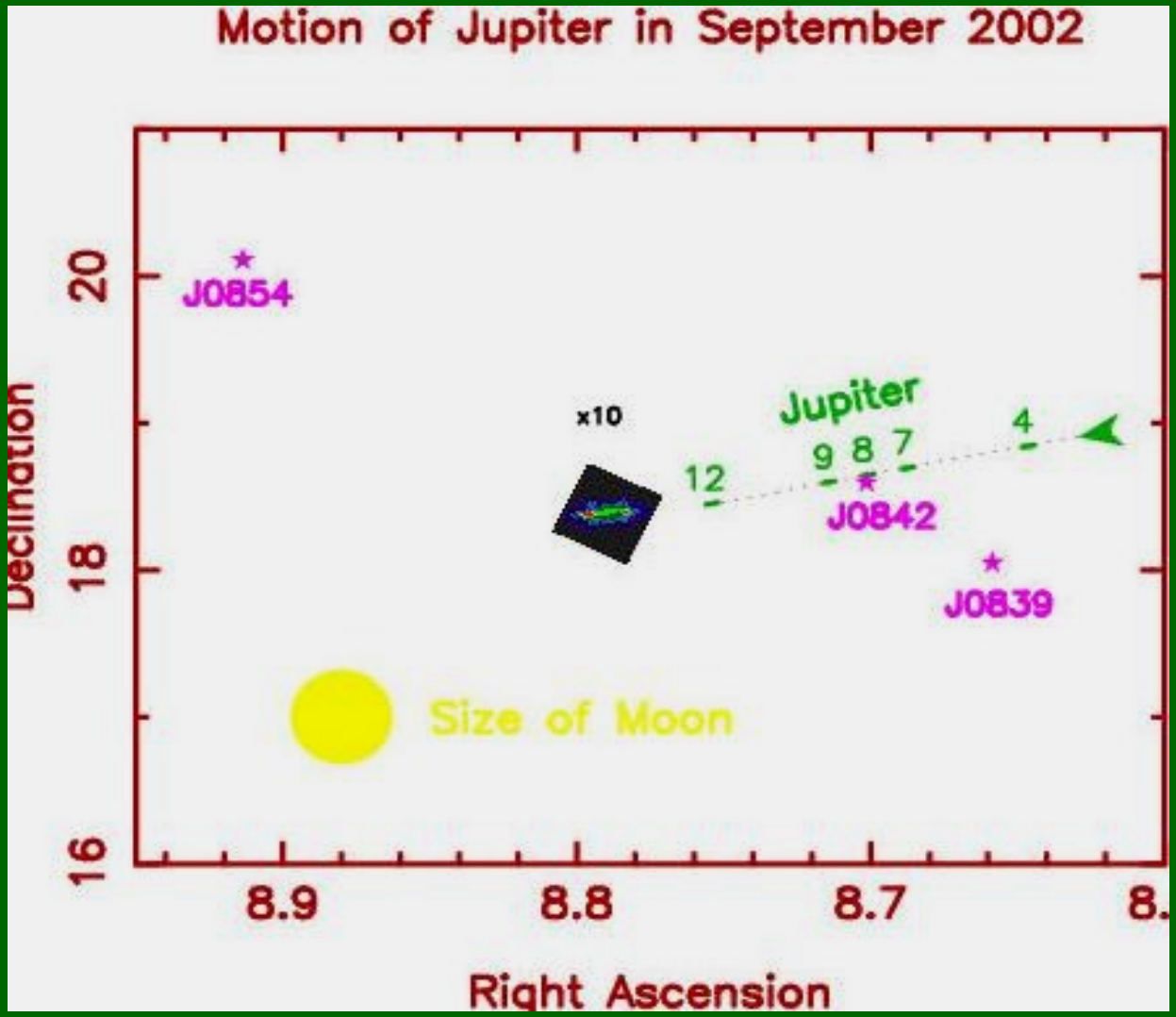
JUPITER BENDING EXPERIMENT

Very Long Baseline Array

VLBA



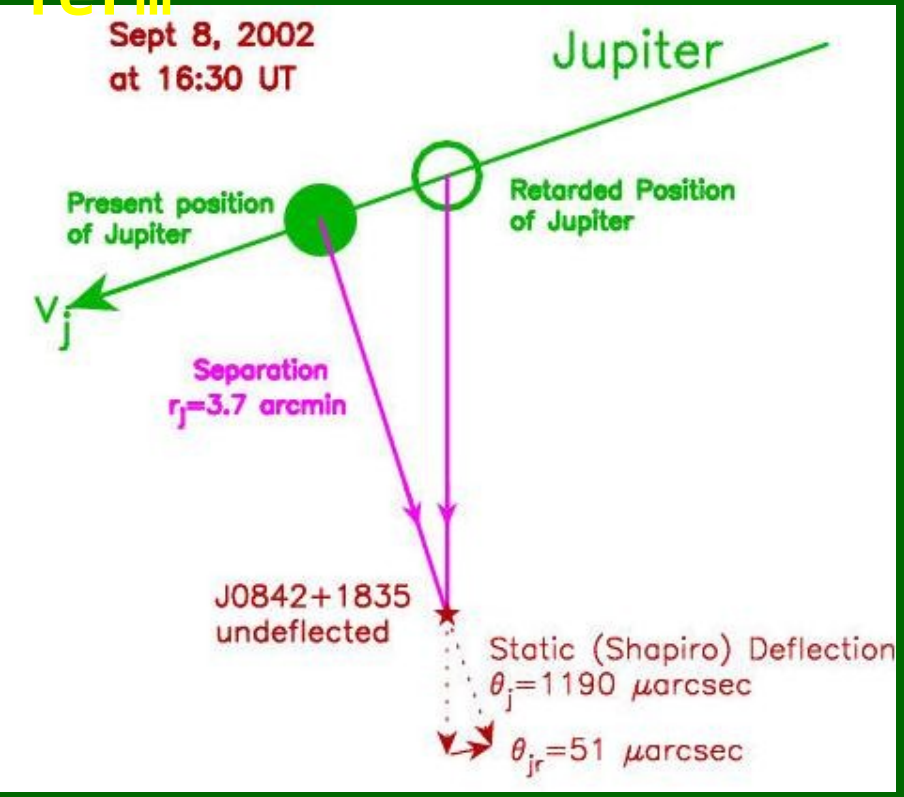
Effelsberg, Germany



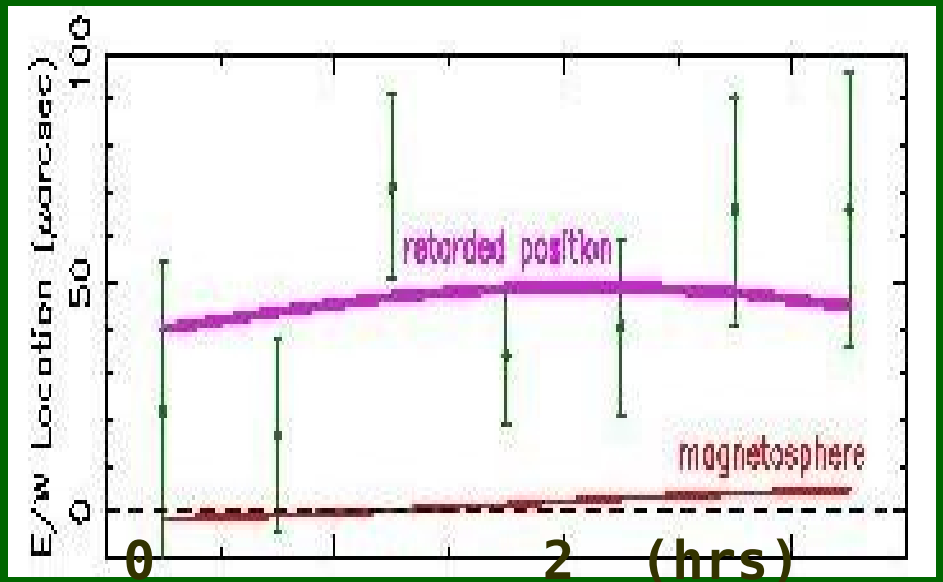
Observe on five days. Sept 8 is the most important day.

Redundancy needed to establish realistic error

Deflection Aberration Term



J0842 position during Sept Aberration term only



Aberration term measured as (50 +/- 10) μarcsec

omalont and Kopeikin, ApJ, **598**, 704, 2003

EXPERIMENTAL RESULTS

- Quasar position measured to 10 μas accuracy
  over a 5 hour period. VLBA astrometric accuracy

- Retarded deflection term
  θ_{jp} = 0.98 +/- 0.19 times GR prediction.
  The radial deflection term was determined to
  about 1% accuracy. (It was only Jupiter!)

- Interpretation of results – controversial

RETARDED DEFLECTION INTERPRETATIONS

•Kopeikin (2001,2004) – Associated with the finite speed of gravity
and gravito-magnetic effects [(1/c)**v**· **B** force in Electro-magnetism]

•Will (2002) – Measured PPN parameter α_1. See

http://wugrav.wustl.edu/people/CMW/speedofGravity.html

•Asada (2002) – The speed of light (experiment measured
the physical speed of light from the quasar to 20% accuracy)

•Samuels (2003) – Nothing of significance (experiment did

FINAL WORD?

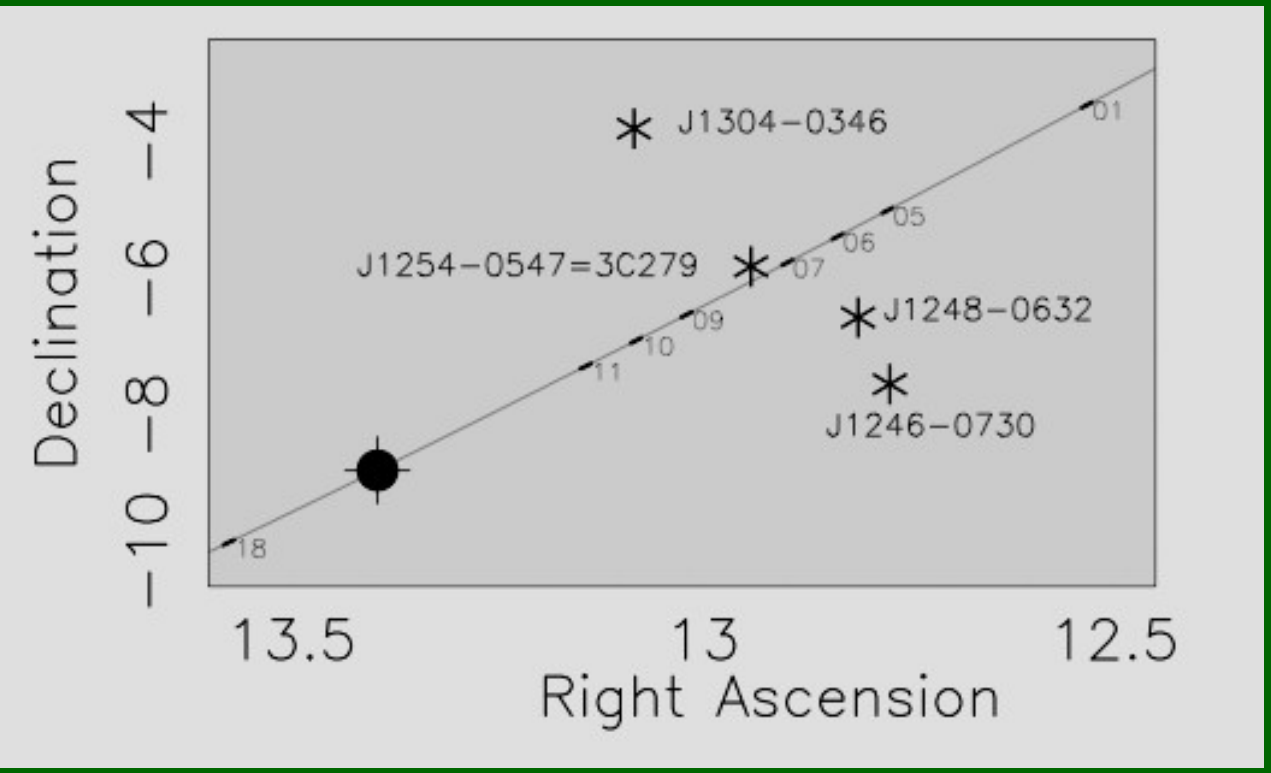
ment that the experimental results are reasonable,
gardless of the interpretation.

r understanding of GR equations, especially the
reful consideration of the speed of light and gravi
the Einstein-Maxwell formulations.

alization of GR from pure Einstein equations is
t obvious. PPN one approach, Kopeikin's another

e speed of gravity a $(v/c)^2$ or a (v/c) effect?
ny say second order only
peikin and some others say that it is first order
in the interaction of light and gravity.

Solar Deflection Experiment in October 2005



--Use VLBA to measure the relative positions of sources

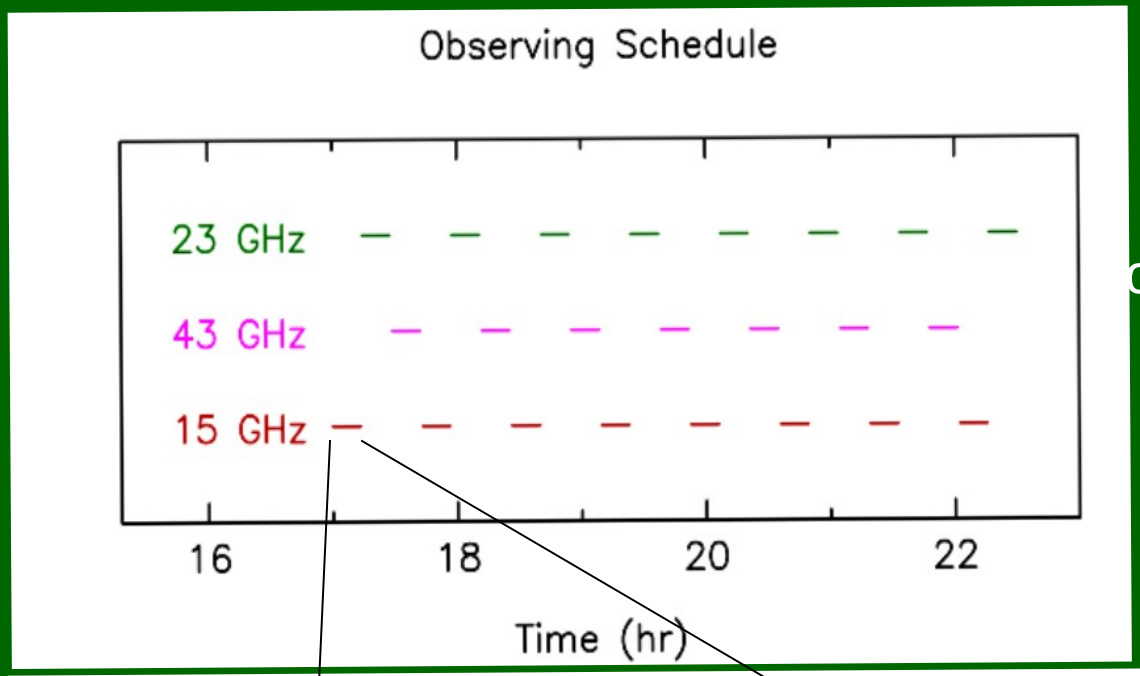
--8 observing days, each 5 hr

On Oct 06 and 07, two or more sources were too close to the sun <2°. Coronal jitter > 1 mas for time scales <5 sec!!

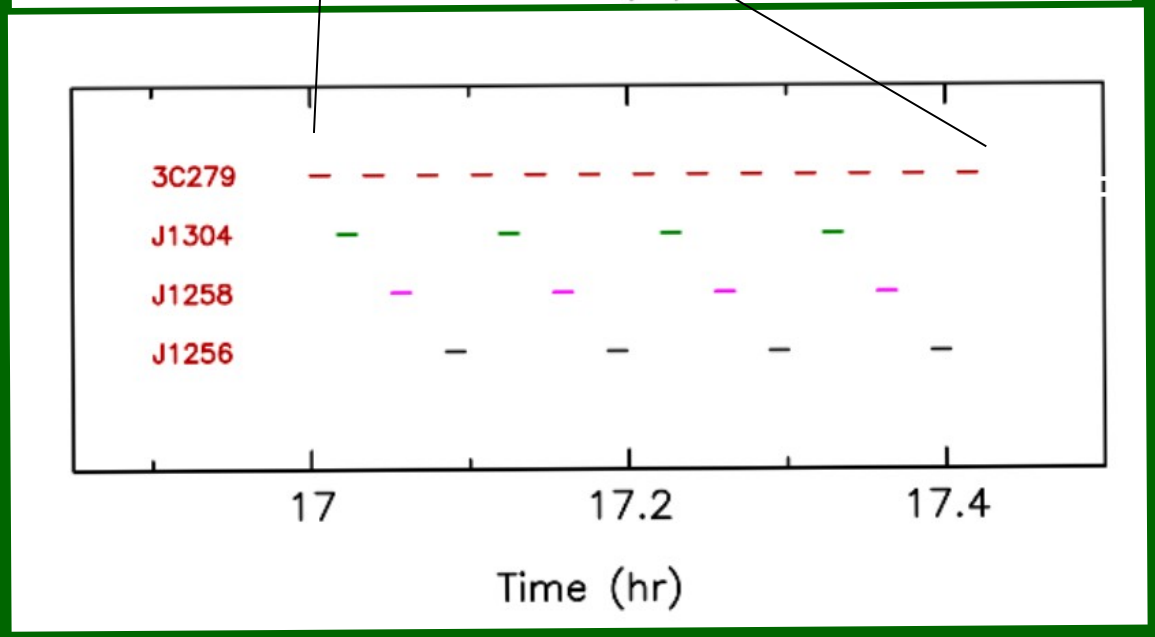
On Oct 05 and 09, coronal bending large, but removable

Interesting coronal physics, but not astrometrically valid

EXPERIMENTAL SCHEME



or each 5 hour observati
on each day, alternate
frequencies every 20 m



r each 20 min block
cycle among four sourc
using 3C279 as the mai
calibrator

EXPERIMENTAL REDUCTIONS

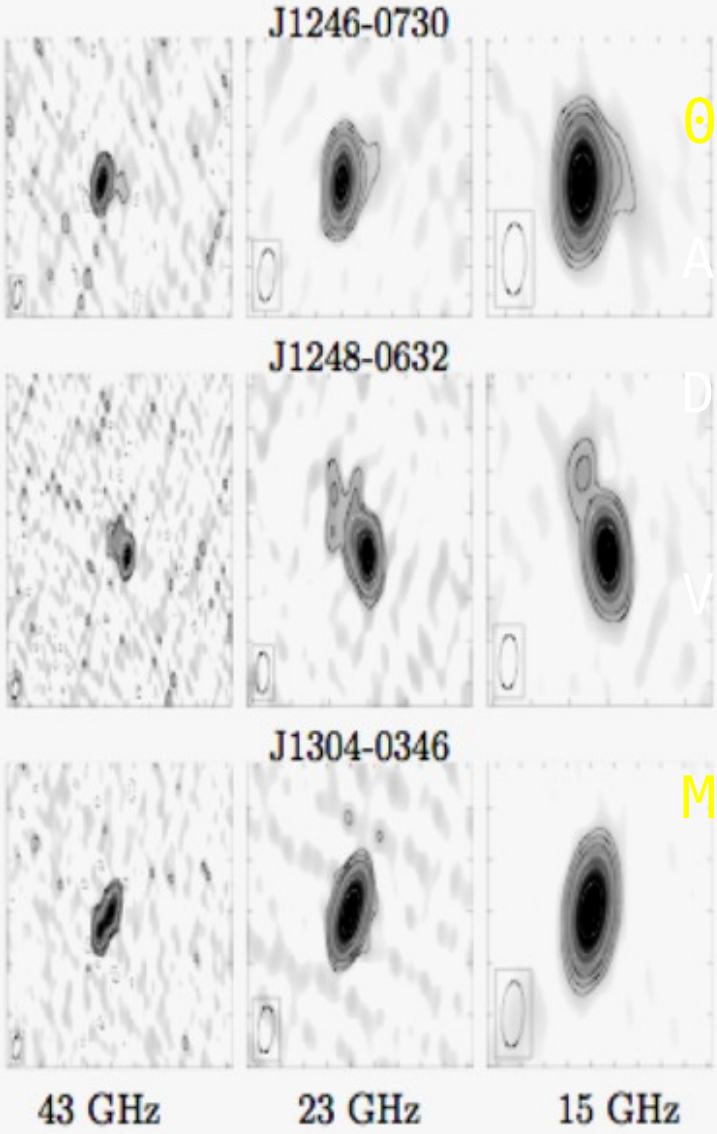
Accurate Calc/solve models plus improve tropospheric model,
including solar deflection assuming γ=1, applied to data
before analysis. Egs. Null experiment if GR is correct.

Hence additional position change caused by corona and residual
atmosphere and (γ-1) bending.

Typical position precision is 0.04 mas (compare with Jupiter exp)

Nominal differential gravitational bending at 3^{o} sun separation is
1.76” / 12 (solar radii) / 2 = 70 mas
0.04 / 70 = 0.5x10^{-3} γ sensitivity
FOR ONE SOURCE/PAIR on ONE DAY

Structure of Sources

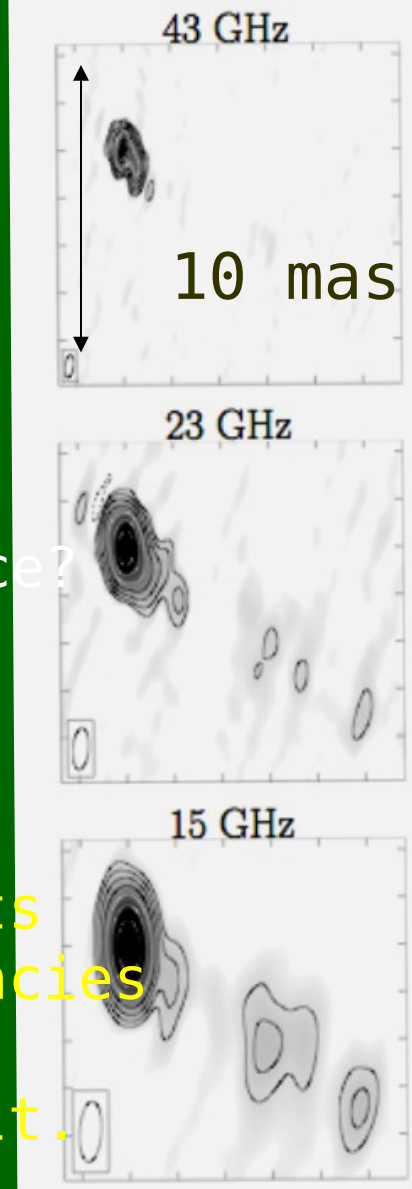


0.02 mas needed

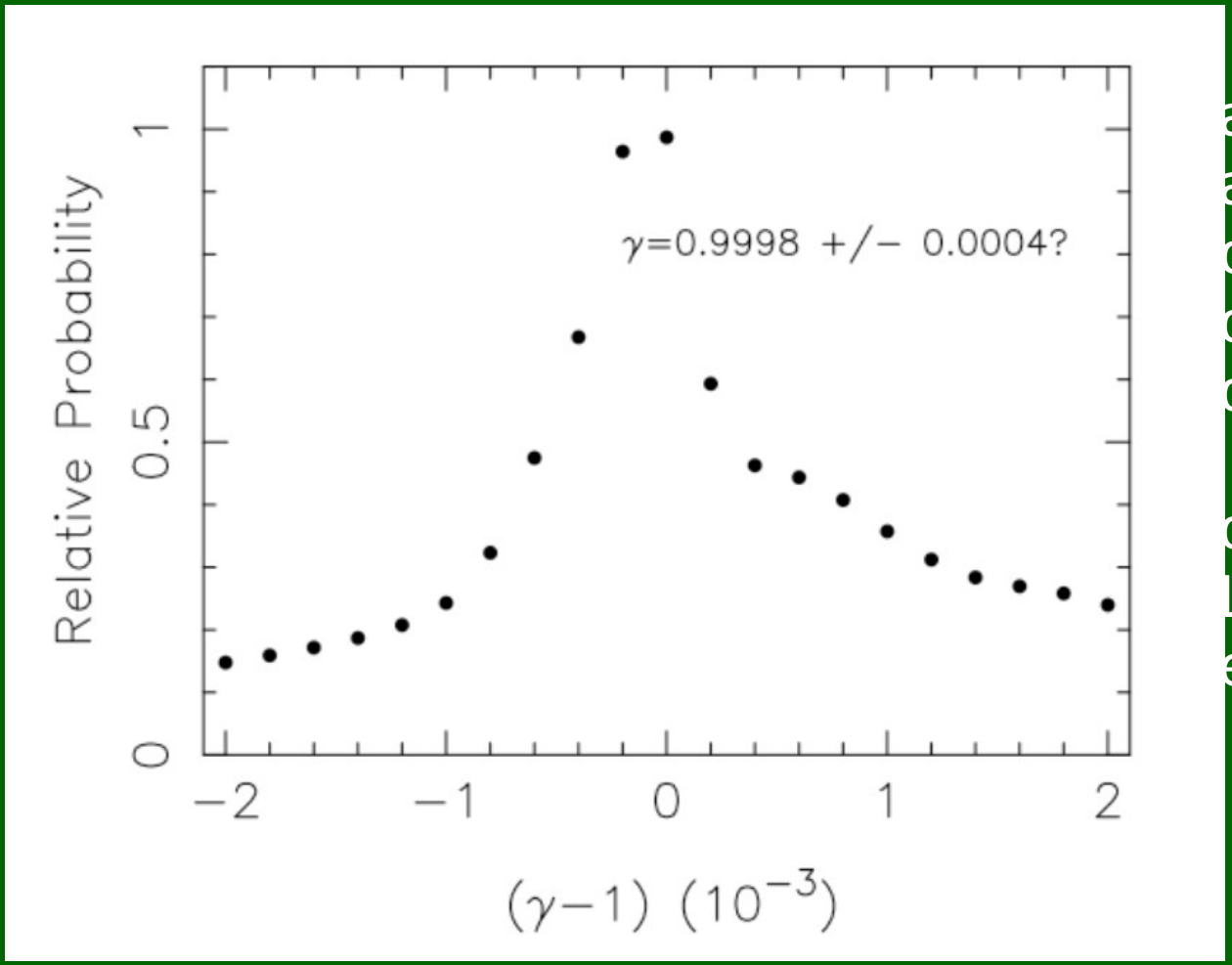
Angular sizes are
0.1 to 5 mas!
Different at three
frequencies
Coronal difference?
Variable??
a little

Must remove
structure effects
register frequencies
at 90% level
Not too difficult.

3C279



TENTATIVE RESULTS



ail to positive sid
aused by three high
oints out of the 20
oints where coronal
orrection was large

ontinuing, but best
LBI results by at
east a factor of 3.

AN DO A FACTOR OF 3 BETTER.
by better experimental technique.